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ABSTRACT

The organization of nine selected cognitive abilities from Guilford's structure-of-intellect model (SI) was explored in a sample of Spanish-English bilingual students. One hundred and ninety-four seventh and eighth graders were assigned to take a battery of nine cognitive ability tests in Spanish or English. The nine tests measured convergent production of semantic material, convergent production of figural material and divergent production of semantic material. Separate factor analyses for each language version resulted in two different factor structures. The factor structure based on the English test battery yielded a verbal-ability factor, a spatial-ability factor, and a relational-ability factor. The Spanish test battery resulted in a convergent-verbal-spatial ability factor, a divergent-semantic ability factor, and a sequential-reasoning ability factor. Results indicated that the cognitive abilities of bilingual children are multidimensional in structure; that the organization of these abilities is different from that hypothesized by Guilford's model; and that this organization is different when the student is tested in Spanish versus English. Recommendations are made for teachers, researchers, and test authors involved in bilingual education. (Author/JAC)

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Comparison of the Factor Structure of Selected Cognitive Abilities in Bilinguals

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Comparison of the Factor Structure of Selected Cognitive Abilities in Bilinguals

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The organization of nine selected cognitive abilities from Guilford's structure-of-intellect model (SI) was explored in a sample of 194 Spanish-English-bilingual students. These seventh and eighth graders were randomly assigned to take a battery of nine cognitive ability tests in Spanish or English. Separate factor analyses for each language version resulted in two different factor structures. The factor structure based on the English test battery yielded a Verbal-Ability factor, a Spatial-Ability factor, and a Relational-Ability factor. The Spanish test battery resulted in a Convergent-Verbal-Spatial Ability factor, a Divergent-Semantic Ability factor, and a Sequential-Reasoning Ability factor.

Comparison of the Factor Structure of
Selected Cognitive Abilities in Bilinguals

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In order to explore the organization of cognitive abilities and the relation of specific abilities to achievement for English-Spanish bilinguals, this study integrated portions of Guilford's multidimensional structure-of-intellect model (SI) with theories concerning bilingual cognitive abilities. Specifically, this research compared the structure of nine cognitive ability tests taken from Guilford's SI model when given in English versus Spanish. The nine tests measured the following abilities: convergent production of semantic material, convergent production of figural material, and divergent production of semantic material. It was hypothesized that the English versus Spanish factor structures would differ, with the Spanish one resulting in more distinct factors and accounting for more total variance.

As previous research (Jensen, 1974; Lesser, Fifer & Clark, 1965; Semler & Iscoe, 1966) has consistently indicated, various ethnic groups perform differently on both intelligence and achievement tests. Kleinfeld (1973) has pointed out that this difference may be the result of a unidimensional definition of intelligence rather than a multidimensional definition which would allow for differences in the organization of abilities in various ethnic groups. Other researchers (Darcy, 1963; DiVesta, 1974; Gaardner, 1975) have stated that the problem is even more complicated when the child is also bilingual. The fact that a child is usually not tested in the dominant language might explain the difference. As Anastasi (1968) stated: "In testing any bilingual groups...the possible influence of a language handicap on test performance must be given serious consideration" (p. 243).

Kleinfeld (1973) also argued that different cultures may foster different abilities in their members. These abilities have not been isolated to date because researchers have used a highly western culture-bound concept of intelligence. "It is the concept of intelligence as a single general ability that is in large part responsible for the consistent findings of 'intellectual inferiority' among most culturally different groups" (p. 341). The hypothesis that "different kinds of intellectual skills are fostered or hindered in various environments" was also suggested by Lesser, Fifer and Clark (1967, p. 92). They argued that the way to measure these different abilities was by studying the pattern (organization) of various cognitive abilities within each ethnic group. They proposed that the "identification of relative intellectual strengths and weaknesses of members of different cultural groups must now become a basic and vital prerequisite to making enlightened decisions about education in urban areas" (p.98).

A large body of research has been established concerning the performance differences on intelligence tests and on achievement between Spanish-bilingual and English-speaking American children. Thus the focus of this research was on an examination of whether these differences are the function of the test language used (English) and/or the use of a unidimensional definition of intelligence. This research was based on two theoretical frameworks: Guilford's SI model and bilingualism as an interference in both the measurement of intelligence and of cognitive processing. It was theorized that the testing of children in English and the use of unidimensional tests serves to depress scores

for bilingual subjects and, further, that bilingualism creates a different structure or oganization of cognitive abilities.

Method

Sample

The sample for this study was 194 junior high school students (69 seventh graders and 125 eighth graders) who were enrolled in a bilingual program in a large metropolitan school district. Since bilingualism was defined as the ability to read and write in both Spanish and English, the bilingual supervisor and the classroom teachers selected the students based on this criterion.

Test Battery

Nine SI tests were selected from the 98 tests that have been developed to test the 120 abilities within the SI model (Guilford & Hoepfner, 1971). Four criteria were used in the selection of the nine tests: practicality of the tests and testing procedures, the desire to include tests of both verbal and nonverbal content, the desire to include tests that measured both convergent and divergent operations and relevance to science achievement (for future analyses).

These nine tests were selected with the expectation that three factors would be identified. Thus the divergent-semantic factor was represented by the following tests: Alternate Uses, What Would Happen, and Names for Stories. The hypothesized convergent-semantic factor was represented by Word Grouping, How Things Change, and Verbal Analogies. Hidden Figures, Figure Analogies, and Match Problems IV measured the convergent-figural factor.

All tests were translated into Spanish by the author (a former Spanish teacher), the bilingual supervisor (a native speaker) at the school involved and by a university professor of bilingual education who was also a native speaker. These tests were pilot tested on a small sample prior to this study.

The reliabilities of the tests ranged from .52 to .94 with an average reliability of .78. The reliability of Spanish versions was lower in several cases. Both construct and predictive validity have been established by Guilford (1967) and other research (Keller, 1973; Merrifield & Hummel-Rossi, in press; Ukens, 1972).

Procedure

The 194 students were randomly assigned to take the SI test battery in either English or Spanish. The method of treatment assignment was chosen to avoid obtaining a practice effect previously found by Anastasi and Cordova (1953) and Quay (1971). The testing took place over two days with bilingual teachers administering the tests.

Analyses

The data from the English versus Spanish tests were factor analyzed separately using principal factor analysis with squared multiple correlations as initial communality estimates with varimax rotation. After satisfactory solutions were obtained, the factors for each group were compared using Tucker's coefficient of congruence (Harman, 1967). The degree to which each factor structure approximated simple structure was also assessed. Finally a comparison of the proportion of total variance accounted for in each solution was made.

Results and Discussion

Both analyses resulted in three factors (see Table 1 and Table 2). In neither case did the three factors match the hypothesized factors based on Guilford's model (convergent semantic, convergent figural and divergent semantic). In addition, the composition of these two factor solutions was different, since no coefficient of congruence exceeded .85.

In the English factor solution the three factors were Verbal Ability, Spatial Ability and Relational Ability (see Table 1). Consistent with previous research on minority groups (Hennessy, 1974; Semler & Iscoe, 1966), those tests which were semantic (verbal) in content loaded together. This cohesion could be seen as further evidence for the theory that test language does make a difference for bilingual students, since the majority of the variance in the five semantic tests was accounted for by verbal ability. Thus it appears that the verbal content of these tests is more important than the operation (convergent versus divergent). In previous research (Hennessy, 1974; Semler & Iscoe, 1966) a spatial ability factor has often loaded on the verbal factor but in this study it did not. This difference in factor composition may be due to the use of Guilford's multidimensional model and the use of several tests in the present research where previous research did not do so.

The Spanish factor structure was composed of three factors: Convergent-Verbal-Spatial Ability, Divergent-Semantic Ability, and Sequential-Reasoning Ability (see Table 2). These three factors more closely approximated the operations dimension of the Guilford model, whereas the solution based on the English testing more closely replicated the content distinctions. The first factor, Convergent-Verbal-Spatial Ability, was a combination of the tests measuring both the figural and semantic areas of convergent production. The second factor, Divergent-Semantic Ability, consisted of those tests that were from Guilford's divergent-semantic-production factor. This finding indicates support for the idea that bilingual children have previously unidentified creative talent (DiVesta, 1974; Peal & Lambert, 1962) because these tests are often considered measures of creativity (Guilford, 1967). The third factor was the Sequential-Reasoning-Ability factor and was represented only by How Things Change. Also the Spanish solution did not account for more total variance than the English solution (43% versus 52%), although it more closely approximated simple structure.

In summary, there were three major findings in this study. First, the cognitive abilities of bilingual children are multidimensional in structure.

Second, the organization of these abilities is different from that hypothesized by Guilford's model. Third, the organization of these abilities is different when the student is tested in Spanish versus English.

Implications

This research has several implications for educational practices and for future research. Regarding educational practices, Lesser, Fifer, and Clark (1967) have stated that the "most important implications of research on patterns of mental ability relate to practical efforts to determine optimum educational conditions and the most valid assessment instruments for children from diverse backgrounds" (p. 2). Four suggestions for optimizing educational conditions are made here based on the results of this study.

First, these data suggest that the language of test administration may influence the results obtained and results of studies on bilingual students should be evaluated in light of this finding.

Second, this research indicates that cognitive abilities are multidimensional for bilingual students as well as for monolinguals. Research of this type should discourage teachers and administrators from using unidimensional tests to measure cognitive ability or to group students.

Third, given that different information may be obtained depending on the test language, teachers should attempt to get baseline information about a student's skills in their dominant language or in both languages. If both languages are used, the teacher could develop an individualized learning program for the student that integrates and optimizes the test information. In addition, the multidimensional definition and measurement of abilities would allow for a specific diagnosis and prescription for learning for each student based on each academic area.

The last suggestion is that test developers and teachers use more open-ended (short answers) questions than multiple choice questions. The students in the present study did better on short answer tests (Alternate Uses, What Would Happen, Names for Stories, Word Grouping and Hidden Figures) than on multiple choice tests. In brief discussions with both the students and the teachers, it became evident that the students enjoyed the open-ended tests and were very apprehensive about the multiple choice tests. Perhaps one reason minority groups often score lower on tests is because of the test format.

Table 1

Varimax Rotated Factor

Matrix for English

Version of SI Tests

Test	Loadings: Verbal Ability	Spatial Ability	Relational Ability	h^2
Word Grouping	.68	.29	.14	.56
How Things Change	.09	-.06	.38	.16
Verbal Analogies	.54	-.02	.35	.41
Hidden Figures	.17	.57	.15	.38
Figure Analogies	.11	.46	.83	.91
Match Problems	.11	.78	-.08	.63
Alternate Uses	.70	.13	-.07	.52
What Would Happen	.55	.23	.27	.42
Names for Stories	.80	.07	.18	.68
Σ of squared factor loadings	2.25	1.31	1.11	4.67

Note. All loadings $\rangle$.35 are underlined.

Table 2

Varimax Rotated Factor Matrix for Spanish Version of SI Tests

Test	Loadings: Convergent-Verbal-Spatial Ability	Divergent-Semantic Ability	Sequential-Reasoning Ability	h^2
Word Grouping	.49 (.54)[a]	.02	-.02	.24
How Things Change	-.09	-.01	.76 (.84)	.59
Verbal Analogies	.65 (.72)	-.07	-.22	.48
Hidden Figures	.49 (.54)	.08	.02	.25
Figure Analogies	.56 (.62)	-.24	-.04	.39
Match Problems IV	.67 (.74)	.10	.12	.47
Alternate Uses	-.00	.65 (.72)	-.07	.43
What Would Happen	.02	.61 (.67)	.11	.38
Names for Stories	-.00	.80 (.88)	-.03	.64
$\sum$ of square factor loadings	1.67	1.51	.68	3.87

Note. All loadings $\rangle$ .35 are underlined.

[a]All loadings in parentheses are revised loadings adjusted for the difference in variance between the two solutions by multiplying each loading by 1.1.

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